Report 5 - Stochastic methods for finance

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April 28, 2023

Abstract

In this report i compute the implied volatility surface and the greeks for a real asset: Baidu, Inc using data from Yahoo Finance and VBA scripts.

1 Introduction

Volatility smiles are implied volatility patterns that arise in pricing financial options. It is a parameter that is needed to be modified for the BlackScholes formula to fit market prices. In particular for a given expiration, options whose strike price differs substantially from the underlying asset's price command higher prices (and thus implied volatilities) than what is suggested by standard option pricing models. These options are said to be either deep in-the-money or out-of-the-money.

Graphing implied volatilities against strike prices for a given expiry produces a skewed "smile" instead of the expected flat surface. The pattern differs across various markets. Equity options traded in American markets did not show a volatility smile before the Crash of 1987 but began showing one afterwards. It is believed that investor reassessments of the probabilities of fat-tail have led to higher prices for out-of-the-money options.

Traders allow the implied volatility to depend on time to maturity as well as strike price. Implied volatility tends to be an increasing function of maturity when short-dated volatilities are historically low. This is because there is then an expectation that volatilities will increase. Similarly, volatility tends to be a decreasing function of maturity when short-dated volatilities are historically high. This is because there is then an expectation that volatilities will decrease. Volatility surfaces combine volatility smiles with the volatility term structure to tabulate the volatilities appropriate for pricing an option with any strike price and any maturity.The shape of the volatility smile depends on the option maturity.

2 Methods & Results

First i choose a Baidu, Inc. (BIDU) stock, in date 24 April the stock price is S=122,53$. Then i choose different call options with different K, T and implied volatilities to provide the implied volatility surface that is in figure 1. The data is taken from Yahoo Finance and it is provided in the table below. Then i compute the greeks for the call option with the values taken from table 1 and the interest rates from LIBOR and also i consider the dividend rate q null. For the timeframes where the interest rate was not available i did an interpolation using the available ones. So using a VBA script [3] i computed the greeks and plotted them in figures from 2 to 4.

	1 month	2 months	5 months	9 months	14 months
95$	70,91%	62,74%	58,18%	62,92%	71,91%
100$	63,23%	57,28%	55,70%	55,63%	70,36%
105$	56,93%	54,35%	53,62%	54,26%	64,23%
110$	53,76%	51,67%	51,53%	52,57%	54,34%
115$	50,73%	50,32%	50,29%	56,00%	52,62%
120$	46,73%	48,04%	48,94%	50,53%	50,89%
125$	45,94%	46,78%	47,93%	50,14%	50,76%
130$	45,25%	46,14%	46,92%	49,16%	50,12%
135$	43,30%	45,47%	46,24%	48,50%	49,87%
140$	46,36%	45,97%	45,79%	47,94%	49,81%
145$	46,90%	46,22%	45,63%	47,48%	50,48%
150$	45,40%	43,97%	44,33%	46,98%	49,41%
155$	46,54%	42,77%	43,63%	46,76%	49,36%
160$	48,23%	43,23%	42,83%	47,05%	48,21%

Table 1: Implied volatilities for T=1,2,5,9,14 and K=95,...,160.

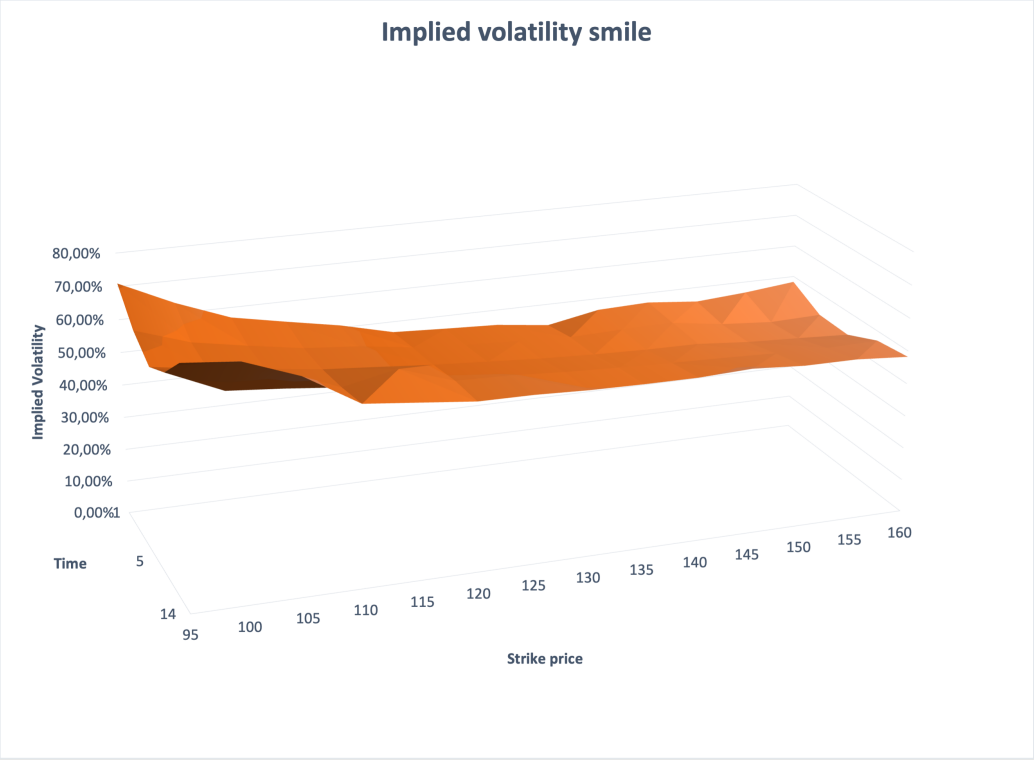

Figure 1: Implied volatility surface for Baidu.

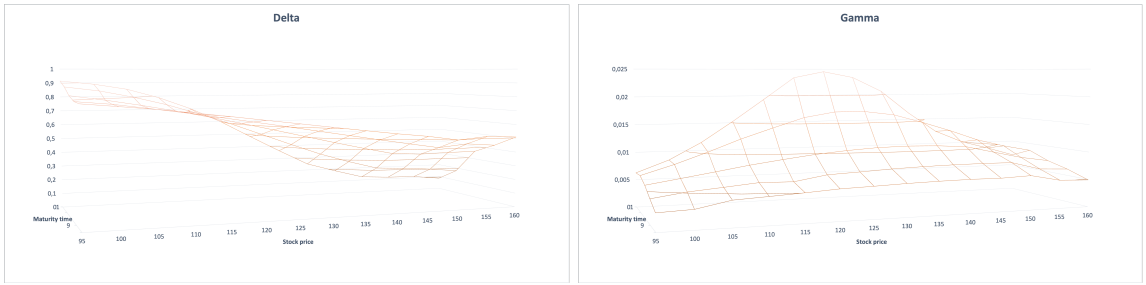

Figure 2: Delta and Gamma

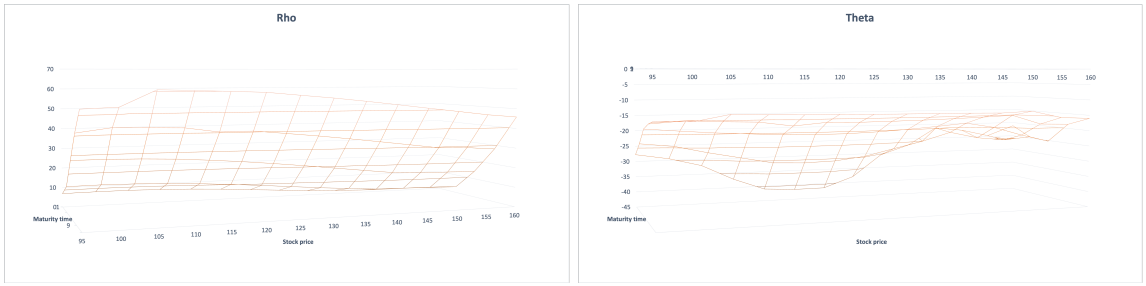

Figure 3: Rho and Theta

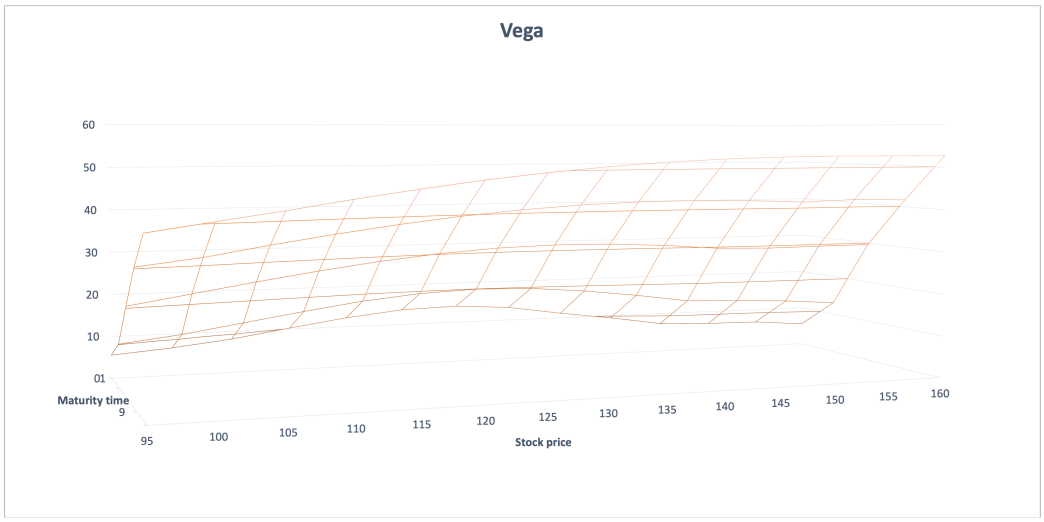

Figure 4: Vega

3 Conclusions

From the implied volatility graph is possible to see the characteristic volatility smile for small T and is also possible to notice the flattening of the surface as the maturity increases. This behaviour is expected since increasing T the Black-Scholes formula tends to approximate better and better the real market price and therefore we expect to see the flat volatility curve predicted by the model. From the greeks computation it is possible to see that each one has a familiar behaviour, very similar to the one shown in theoretical example in report 4.

Appendix

VBA codes are taken from these links:

- Black Scholes Greeks: `https://sites.google.com/view/vinegarhill-financelabs/black-scholes\-merton/black-scholes-greeks`
- used for testing greeks: `https://investexcel.net/black-scholes-greeks-vba/`